RUNNING HEAD: RELATIONAL COGNITION

Moving beyond the distinction between System 1 and System 2: Conditioning, implicit evaluation, and habitual responding might also be mediated by relational knowledge

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In press. Experimental Psychology.

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Abstract

It is generally assumed that relational knowledge is the foundation of higher cognition such as (analogical and conditional) reasoning, language, the use of relational categories, and planning. Dual-system models (e.g., Kahneman, 2011) that divide the realm of cognition into two systems with opposing properties (e.g., fast vs. slow, intentional vs. unintentional, conscious vs. unconscious, associative vs. propositional) foster the view that other psychological phenomena are not relational in nature. In this paper, I argue that the impact of relational knowledge is more widespread than dual-system models imply. More specifically, I review evidence suggesting that also Pavlovian conditioning, implicit evaluation, and habitual responding are mediated by relational knowledge. Considering the idea that relational knowledge underlies also fast, unintentional, unconscious, and seemingly associative psychological phenomena is not only theoretically important but also reveals new opportunities for influencing thinking and behavior.

Keywords: cognition, relational knowledge, Pavlovian conditioning, implicit evaluation, habits, dual-system models

As a science of information processing, cognitive psychology aims to uncover the knowledge that underlies thinking and behavior. In this context, much attention has been directed at relational knowledge, which can be defined as information about the way in which elements are related. Consider the statement that John loves Mary. The knowledge implied by this statement is relational in that it specifies (a) the relation between John and Mary (i.e., loves) and (b) the role that each element plays within that relation (i.e., John is the lover and Mary is the beloved; Halford, Wilson, & Phillips, 2010). Mental representations can be described as relational if they capture relational knowledge. Simple associative links between representations in memory (e.g., John --- Mary) are not relational in this sense because they do not specify the nature of the relation between the elements or the role that elements have within a relation. More complex associative structures could represent relational knowledge. When they do so, these structures qualify as relational representations. However, it is still not entirely clear how relational knowledge can be adequately represented in complex associative structures such as connectionist networks (Hummel, 2010).

At present, it is generally accepted that relational knowledge underlies a range of phenomena that are often referred to as instances of higher cognition, such as (analogical and conditional) reasoning, the use of language and relational categories, and planning (e.g., Halford et al., 2010). It indeed seems a logical necessity that these phenomena require relational knowledge. For instance, relational knowledge allows one to appreciate the structural consistency between dots on a map and buildings in a city (Halford et al., 2010). Such structure consistent mappings lie at the core of analogies (e.g., dot A is to dot B as building A is to building B). Likewise, many aspects of language are inherently relational, most prominently the human ability to refer to complex relational categories (e.g., brother-in-law).

In this paper, I consider the possibility that also phenomena that are not typically

considered to be instances of higher cognition are mediated by relational knowledge. If one defines higher cognition as any psychological phenomenon that is mediated by relational knowledge, one could thus say that the aim of this paper to reexamine the scope of higher cognition. If one by definition limits higher cognition to phenomena such as reasoning, language, and planning, then the aim of this paper is to examine which psychological phenomena other than instances of higher cognition rely on relational knowledge. Regardless of how higher cognition is conceptualized, this paper aims to reassess the role of relational knowledge in human thinking and behavior.

A reassessment of the role of relational knowledge is important in light of the pervasiveness of the alignment assumption in psychological science. This assumption, which is most clearly manifested in dual-system models of cognition (e.g., Evans, 2003; Kahneman, 2011; Sloman, 1996; Strack & Deutsch, 2004), implies that different ways of dividing the realm of cognition produce the same parts (Melnikoff & Bargh, 2018; Moors & De Houwer, 2006a). For instance, Kahneman (2011) distinguishes between System 1 and System 2 thinking not only on the basis of speed (fast vs. slow) but also in terms of intentionality (unintentional vs. intentional), consciousness (unconscious vs. conscious), and the nature of processing (associative vs. propositional). This implies that all fast thinking is also unintentional, unconscious, and associative whereas all slow thinking is also intentional, conscious, and propositional.

Although some have recently argued that even proponents of dual-system models never took serious the idea that these distinctions are perfectly aligned (Pennycook, De Neys, Evans, Stanovich, & Thompson, 2018), dual-system models at the very least draw attention away from the complexity of the relations between the various properties of psychological phenomena (see Moors, 2016, for an excellent exploration of this complexity). Most relevant for the present paper, dual-system models foster the idea that relational knowledge is

important only for System 2-type thinking (i.e., thinking that is slow, intentional, conscious, and propositional). Indeed, the conclusion that relational knowledge is relevant for System 2 but not System 1 follows naturally from the assumptions that (1) there are two cognitive systems with multiple opposing properties (i.e., the dual-system alignment assumption), (2) higher-order cognition such as reasoning, language, and planning are instances of System 2 thinking (e.g., Kahneman, 2011), and (3) higher-order cognition relies on relational knowledge.

When, however, the alignment assumption is rejected (as is now done even by proponents of dual-system models), one should allow for the possibility that also fast, unintentional, unconscious, or seemingly associative ways of thinking and behaving rely on relational knowledge. It is precisely this possibility that I examine in this paper. More specifically, the focus will be on Pavlovian conditioning, implicit evaluation, and habitual responding. These three phenomena are particularly interesting in that they are often seen as prototypical examples of psychological phenomena that are fast, unintentional, unconscious, or associative. Hence, in line with a dual-systems perspective, it is often assumed that these phenomena are mediated by simple associative representations rather than relational knowledge. Recent evidence, however, suggests that relational knowledge might be crucial for each of these phenomena. If this is the case, then relational knowledge would be much more important than previously considered. After reviewing the relevant evidence, I point out that exploring the role of relational knowledge in automatic and seemingly irrational ways of thinking and behaving can result in new ways of tackling psychological problems.

Evidence for a Widespread Impact of Relational Knowledge

Pavlovian Conditioning

As an effect, Pavlovian conditioning refers to changes in behavior that are due to the spatio-temporal pairing of events (Bouton, 2016; De Houwer, Barnes-Holmes, & Moors,

2013). For instance, in fear conditioning, pairing an originally neutral light with an aversive electric shock results in the light evoking fear (Craske, Hermans, & Vansteenwegen, 2006). Likewise, evaluative conditioning is a change in liking of an originally neutral stimulus that occurs as the result of pairing this stimulus with a valenced (i.e., positive or negative) stimulus (De Houwer, 2007). Within cognitive psychology, it is most often assumed that Pavlovian conditioning effects are mediated by the formation of simple associations between representations in memory (Bouton, 2016; see De Houwer, 2018a, for a historical analysis). Although different association formation models have been put forward that differ with regard to their assumptions about the conditions under which associations are formed and influence behavior (see Bouton, 2016, for a review), they all share the assumption that conditioning occurs only if pairings result in the formation of associations. Those associations are hypothetical structures in memory via which activation can spread from one representation to another, thereby allowing stimuli to evoke responses they did not evoke before the stimulus pairings.

During the past decade, however, my colleagues and I have argued that Pavlovian conditioning (in humans) is mediated by the formation of propositional representations (De Houwer, 2009, 2018b; Mitchell, De Houwer, & Lovibond, 2009). In essence, propositions are informational units that can specify how things are related. For instance, the propositions "light predicts shock" and "light sometimes co-occurs with shock" both involve the concepts "light" and "shock" but differ in how those concepts are related. Propositions can be vague about the way in which events are related (e.g., "light is somehow related to the shock") and can be irrational (e.g., "light produces the shock") but all propositions are inherently relational in nature. Propositional models postulate that the formation of propositions in Pavlovian conditioning is akin to higher-order reasoning: it involves problem solving that is directed at discovering the way in which events in the world are related. Hence, these models

predict that Pavlovian conditioning and reasoning are moderated by the same variables, including verbal instructions, awareness, and mental load. In the following paragraphs, we highlight some of the evidence supporting this prediction.

First, just like higher-order cognitive phenomena, conditioning in humans is highly sensitive to verbal information. Already since the 1930s, we know that a simple instruction stating that a light will be followed by a shock, results in fear of the light even if the light and shock are never paired (Cook & Harris, 1937). Subsequent research revealed striking parallels between the moderators of fear conditioning via instructions and the moderators of fear conditioning via the actual pairing of stimuli (see Mertens, Boddez, Sevenster, Engelhard, & De Houwer, 2018, for a review, and De Houwer, 2018b, for related evidence on evaluative conditioning via instructions). Moreover, instructions and actual pairings can jointly influence behavior. For instance, during a first phase, Lovibond (2003, Experiment 3) delivered a shock to participants whenever a compound of two colored squares appeared on a computer screen. As a result, each color separately evoked fear. Afterwards, he informed participants that one of the colors is safe (i.e., never followed by the shock), thus implying that the shock on the preceding compound trials was related to the other color. Importantly, such a simple instruction ("this color is safe") increased fear for the other color, demonstrating that actual pairings (i.e., on compound trials) and instructions can jointly determine behavior. Finally, also instructions about the nature of the relation between stimuli (e.g., whether one stimulus is a predictor vs. a cause of the other) have a profound impact on Pavlovian conditioning (e.g., Hughes, Ye, Van Dessel, & De Houwer, 2019; Waldmann & Holyoak, 1992). The fact that Pavlovian conditioning is highly sensitive to verbal instructions fits well with the idea that both pairings and instructions result in propositional (and thus relational) knowledge that provides the basis for changes in behavior.

Second, Pavlovian conditioning depends heavily on awareness of the relations between

stimuli, as well as the availability of working memory resources (see Lovibond & Shanks, 2002, and Mitchell et al., 2009, for a reviews). Since the 1970s, numerous studies have been published in which fear conditioning was observed only in participants who were aware of the stimulus contingencies (e.g., Dawson, & Biferno, 1973). On top of this correlational evidence, experimental studies showed that variables that influence contingency awareness (e.g., the presence of an attention demanding secondary task) also influence fear conditioning. For some time, researchers considered the possibility that some types of Pavlovian conditioning such as evaluative conditioning might not depend on contingency awareness and working memory resources, but recent evidence strongly argues against this possibility (see Corneille & Stahl, in press, for a review). For instance, a meta-analysis showed that contingency awareness is by far the most important moderator of evaluative conditioning, accounting for no less than 36% of the variance (Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010). This heavy reliance of various Pavlovian conditioning effects on contingency awareness and working memory resources parallels findings in research on higher cognition and fits very well with the idea that the construction of relational knowledge relies on working memory (Halford et al., 2010). It is, of course, difficult to exclude the possibility that some instances of Pavlovian conditioning in humans can occur in the absence of contingency awareness and working memory resources. However, after many years of research on this topic, I believe that it is safe to conclude that, if those instances exist in humans, they occur only when very strict boundary conditions are met (e.g., Greenwald & De Houwer, 2017). [1] While it definitely remains worthwhile to look for and document the boundary conditions of those instances of non-relational Pavlovian conditioning (see

1 Propositional theories cannot be dismissed simply on the basis of the fact that also nonhuman animals show Pavlovian conditioning (see De Houwer, Hughes, & Barnes-Holmes, 2016, for a discussion). First, it is possible that similar effects are produced by different mechanisms in different species. Second, it is possible that propositions (and thus relational knowledge) underlies conditioning also in (some) nonhuman animals. For more information on this and other possible objections to propositional models of conditioning, see Mitchell et al. (2009) and De Houwer (2018b).

McLaren et al., 2014, for a discussion of possible candidates), it can no longer be assumed by default that conditioning effects are non-relational in nature. On the contrary, I would argue that the burden of proof is now on those who wish to claim that specific instances of conditioning effects in humans are non-relational.

Implicit Evaluation

Implicit evaluation can be defined as the automatic effect of stimuli on evaluative responses (De Houwer, Gawronski, & Barnes-Holmes, 2013). In less technical terms, it refers to the spontaneous "gut" feelings that people regularly experience. Most often, implicit evaluations are captured using indirect measures such as the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998). As is the case with Pavlovian conditioning, the most popular account of implicit evaluation relies on the notion of simple associations in memory (e.g., Fazio, 2007). More specifically, it is assumed that the representations of valenced stimuli in memory are associated with the representations of the concepts "good" or "bad". Upon presentation of a valenced stimulus, activation of the stimulus representation will spread automatically to those evaluative representations and thus result in an automatic evaluative response.

Although the idea of automatic spreading of activation via associations provides a simple account of the automatic nature of implicit evaluation, it is not the only possible account. Recently, I put forward the idea that implicit evaluation is mediated by propositions (and thus relational knowledge; De Houwer, 2014; see also Mandelbaum, 2016). Whereas the *formation* of propositions might rely on working memory (and thus instructions, awareness, and resources), the *retrieval* of propositions could well be similarity-based and largely independent of working memory as is, for instance, postulated by episodic memory models (e.g., Hintzman, 1986; Logan, 1988; Schmidt, De Houwer, & Rothermund, 2016).

Several interesting predictions have been derived from a propositional account of

implicit evaluation. A first line of research was based on the idea that propositions can result from instructions. Hence, if implicit evaluation reflects propositions, it should be sensitive to instructions. In line with this prediction, simply providing instructions about the evaluative properties of novel stimuli (e.g., Bob helps old ladies cross the street) is enough to produce changes in the implicit evaluation of those stimuli (e.g., automatic positive reactions to Bob; e.g., De Houwer, 2006; Cone, Mann, & Ferguson, 2017; Gregg, Seibt, & Banaji, 2006). One might object that these effects (a) arise only for process-impure measures that capture not only implicit but also explicit (i.e., non-automatic) evaluations, (b) are mediated by changes in explicit evaluations that produce changes in associations, or (c) are limited to novel stimuli. Recent evidence, however, argues against these possible objections. First, it has been shown that instruction-based implicit evaluations can be found on a wide variety of indirect measures (e.g., Van Dessel, Ye, & De Houwer, 2019), as well as on parameters in multinomial processing tree models designed to capture automatic processes (e.g., Smith, Calanchini, Hughes, Van Dessel, & De Houwer, in press). Second, research revealed that instructions can influence implicit evaluations even in the absence of changes in explicit evaluations (Van Dessel, De Houwer, Gast, Smith, & De Schryver, 2016). Third, to the extent that instructions provide diagnostic and credible information, they can alter even long-standing, deeply rooted implicit evaluations. For instance, Van Dessel, Ye, et al. (2019) informed participants about an actual event in the life of Mahatma Gandhi during which he forbade doctors from giving a medicine to his wife, resulting in her death, but later took the medicine himself when he contracted the disease, resulting in his recovery. Simply providing this single piece of verbal information drastically reduced implicit liking of Gandhi on a variety of measures.

A second line of studies examined the impact of relational information on implicit evaluations. For instance, in a study by Peters and Gawronski (2011), participants saw on

each trial the name of a previously unknown person together with a positive or negative trait. Some persons were paired most often with a negative trait whereas other persons were paired most often with a positive trait. Importantly, in certain cases, participants were informed that a person had the traits opposite to the ones shown on the screen. This relational information had a significant impact on implicit evaluations but did not reverse them completely (also see Moran & Ban-Anan, 2013; Moran, Bar-Anan, & Nosek, 2016; Zanon, De Houwer, Gast, & Smith, 2014). This pattern of results could reflect the joint impact of propositions and associations on implicit evaluations but it could also reflect the joint impact of multiple propositions on implicit evaluations, some based on pairings (e.g., "this person co-occurred with positive traits") and some based on relational information (e.g., "this person is good because he was paired with negative traits"; De Houwer, 2018b; Moran et al., 2016). Regardless of whether there is a significant contribution of associative (non-relational) processes, it is now widely accepted that propositions (and thus relational knowledge) have a profound impact on implicit evaluations. Hence, it is time to discard the assumption that implicit evaluation is by default non-relational in nature.

Habitual Responding

Habit research is another stronghold of non-relational, associative theories. In fact, often habitual responding is even defined in terms of a non-relational mechanism, more specifically, the activation of responses via S-R associations. On the basis of this definition, habitual behavior is typically contrasted with goal-directed behavior, that is, behavior that is a function of its consequences (see Wood & Rünger, 2016, for a review). Whereas goal-directed behavior can be based on relational knowledge (i.e., on how a response is related to realizing a goal), habitual responding in this technical sense is banned from the realm of relational cognition on an a priori basis.

Recently, however, serious questions have been raised about the quality of the evidence

for habitual responding in humans. In addition to genuine failures to find evidence for habitual responding (de Wit et al., 2018), alleged demonstrations of habitual behavior were criticized on the basis of inadequate controls for goal-directed processes. As my colleagues and I pointed out in a recent paper (De Houwer, Tanaka, Moors, & Tibboel, 2018), tests for goal-directed processes need to be both sensitive enough (sensitivity criterion) and look for all the goals at which the behavior could be directed (information criterion). Several studies that claimed to have found evidence for habitual responding in humans did not meet these criteria. Consider the well-known study of Neal, Wood, Wu, and Kurlander (2011) showing that people who often eat popcorn in movie theaters continue to eat popcorn in movie theaters when it is stale whereas control participants do not eat the stale popcorn. The behavior of the first group was considered to be habitual because a devaluation of the tastiness of the popcorn did not lead to a reduction of popcorn consumption, suggesting that eating popcorn was not directed at the goal of eating tasty food. It is possible, however, that people who often eat popcorn when watching movies consume popcorn for other reasons than taste, for instance, to have a fuller cinematic experience. Eating stale popcorn might also serve this goal. Hence, the behavior of eating (stale) popcorn could well be goal-directed, be it directed at a goal different than the one that Neal et al. controlled for. Although we do not exclude the possibility that humans sometimes behave in purely stimulus-driven (i.e., habitual) ways, the picture that is emerging now is that goal-directed behavior is the default mode of behaving (Moors, Boddez, & De Houwer, 2017).

When considering this conclusion, it is important to realize that it only concerns habitual responding in the technical sense (i.e., behavior that is a function of the evoking stimulus but not of its current consequences). The term “habit” is often also used in a different sense, namely as behavior that is emitted frequently and/or automatically. There can be no doubt that humans often repeat the same behavior in similar situations and that

behavior can have features of automaticity (i.e., occur in the absence of conscious intentions, fast, or without awareness of the controlling variables; Moors & De Houwer, 2006b). These types of "habitual" behaviors, however, could well be goal-directed (see Aarts & Dijksterhuis, 2000; Bargh, 1990). In fact, more and more researchers are considering the possibility that impulsive behavior is strategic in nature (i.e., directed at goals; e.g., Kopetz, Woerner, & Briskin, 2018), including seemingly irrational behavior as seen in addiction (Baumeister, 2017; Hogarth, 2018).

Within the context of the present paper, it is important to note that associative (i.e., non-relational) models dominate also research on automatic goal-directed behavior (e.g., Bargh, 1990; Moskowitz, 2012). However, it is also possible that automatic goal-directed behavior depends on relational knowledge. In fact, one could argue that goal-representations are inherently relational in that they need to specify how someone relates to an end-state (i.e., the fact I *desire* the end-state) as well as the role that elements have in that relation (e.g., the fact that it is *me* who desires). Also goal-pursuit seems to necessitate the involvement of relational knowledge, more specifically, knowledge about whether and how an action promotes or hinders the realization of the desired end-state. Hence, it would be worthwhile to start exploring the role of relational knowledge in automatic goal-directed behavior.

To recapitulate: Whereas research in humans provided little evidence for habitual responding in a technical sense, human behavior is often habitual in a broad sense. In contrast to what is often argued, however, the latter behaviors might well depend on relational knowledge.

Converging Arguments from Behavioral Research

Unbeknownst to many cognitive psychologists, a large number of psychological scientists still operate within the behavioral research traditions that originated from the work of behaviorists such as Skinner (1953). In this section, I draw attention to the fact that recent

developments in behavioral research are compatible with the idea that Pavlovian conditioning, implicit evaluation, and seemingly habitual behavior are grounded in relational knowledge.

To fully appreciate the merits of this argument, I first need to point out that behavioral and cognitive approaches in psychology have different goals and are therefore not competitors (De Houwer, 2011; Hughes, De Houwer, & Perugini, 2016). Behavioral researchers operate at the functional level of explanation that aims to explain behavior in terms of elements in the environment. Cognitive researchers, on the other hand, operate at the mental level of explanation that documents the mental mechanisms via which elements in the environment influence behavior (Bechtel, 2005; De Houwer, 2011). For instance, whereas behavioral researchers would explain increases in fear of a light in terms of parings of conditioned and unconditioned stimuli (i.e., Pavlovian conditioning as an abstract explanatory behavioral principle), cognitive researchers explain the impact of light-shock pairings on fear for the light in terms of the formation of associations or propositions (i.e., Pavlovian conditioning as a to-be-explained phenomenon). Rather than competitors, both approaches are mutually reinforcing in that knowing more about (the moderators of) environment-behavior relations constrains theories at the mental level whereas theories at the mental level can facilitate the discovery of (moderators of) environment-behavior relations (see Hughes et al., 2016, for a more detailed treatment of these ideas).

Within behavioral psychology, it has been proposed that much of human behavior is relational in nature (e.g., Hayes, Barnes-Holmes, & Roche, 2001). Behavioral researchers consider responding to be relational when it is a function not of a single event (e.g., the presence of a single light) but of the relation between events. For instance, people can learn to press a left key whenever two identical stimuli are presented on the screen and to press a right key whenever two non-identical stimuli are presented, regardless of what those stimuli are.

Importantly, behavioral researchers have recognized that humans can also respond relationally in arbitrary ways, a phenomenon they refer to as arbitrarily applicable relational responding (Hayes et al., 2001). For instance, the fact that people can respond as if the word "glass" has some functions in common with the object "glass" is considered to be an instance of relational responding that occurs even though the relation between the word and the object is arbitrary (as indicated by the fact that the same object is referred to in French as "verre"). Behavioral researchers have developed functional concepts to describe and analyze this type of relational behavior, paradigms to examine it, and coherent ideas about the learning history that is necessary to establish it (Hayes et al., 2001). Interestingly, despite extensive efforts, until now evidence for (flexible) arbitrarily applicable relational responding has not been found in non-human animals (e.g., Hughes & Barnes-Holmes, 2014; Lionello-DeNolf, 2009). This striking difference between species is consistent with the idea that arbitrarily applicable relational responding (present only in humans) lies as the heart of language (also present only in humans).

In line with the ideas put forward in this paper, it has been argued that also phenomena such as Pavlovian conditioning and implicit evaluation are instances of arbitrarily applicable relational responding. From this perspective, Pavlovian conditioning has much in common with symbolic phenomena like language. More specifically, the pairing of two stimuli is assumed to function as a symbolic cue that signals that the paired stimuli are equivalent in some ways, much like the word "SAME" signals the equivalence of stimuli. For instance, pairing a neutral word with a positive word is assumed to cue people to respond as if the two are equivalent, which includes responding to the originally neutral word in positive ways (De Houwer & Hughes, 2016). Likewise, implicit evaluation has been conceived of as a brief and immediate relational response to stimuli (Hughes, Barnes-Holmes, & Vahey, 2012). Although it is beyond the scope of this paper to provide a detailed discussion of these ideas

and findings (see Hughes & Barnes-Holmes, 2016, Hughes, De Houwer, & Barnes-Holmes, 2016, and Törneke, 2010, for accessible introductions), for the present purposes, it is important to note that these developments in behavioral research fit very well the idea that also Pavlovian conditioning and implicit evaluation are mediated by relational knowledge. Indeed, any mental mechanism that can produce relational behavior must somehow draw on knowledge about how events are related (see De Houwer et al., 2016, for a more detailed discussion).

Broader Implications

Examining whether phenomena such as Pavlovian conditioning, implicit evaluation, and habitual responding are based on relational knowledge allows us to move beyond the dual-system models that been highly influential both within and outside of psychology. A huge merit of the dual-system perspective is that it draws attention to the fact that humans often think and behave in automatic or irrational ways. This insight is undoubtedly one of the main achievements of cognitive psychology. However, the fact that humans think and behave in automatic and irrational ways does not necessitate the existence of a separate, irrational cognitive system (e.g., System 1). There are indeed many ways in which relational knowledge could produce automatic and irrational thoughts and behavior. As I noted earlier on in this paper, relational information could be activated automatically from memory, as is indicated by research on implicit evaluation (De Houwer, 2014). Automatic and irrational behavior can also result from quick-and-dirty inferences that occur automatically but take into account less information than slow and more elaborate inferences (e.g., Van Dessel, Hughes, & De Houwer, in press). In fact, predictive coding accounts of human cognition (e.g., Friston, 2010) imply that automatic inferences provide the foundation of many if not all of our mental abilities. For these and other reasons, more and more psychologists are abandoning dual-system models (e.g., Keren & Schul, 2009; Kruglanski, 2013; Melnikoff &

Bargh, 2018; Moors & De Houwer, 2006a).

Nevertheless, because dual-system models are so intuitively appealing, they are still being used widely as a communicative tool to educate people about the fact that human behavior is often automatic and irrational (e.g., Pennycook et al., 2018). It is important to realize, however, that the simplifications of a dual-system model can blind researchers from the insights offered by the possibility that automatic and irrational behavior is driven by relational knowledge. For example, whereas dual-system views highlight extensive training as the preferred way of changing automatic behavior, a relational perspective implies that instructions and inferential reasoning can be important tools for behavior change, also at the automatic level. This new perspective calls for more research on how relational knowledge shapes automatic and irrational behavior. Whereas it is unrealistic to believe that people can simply be instructed to change their automatic and irrational behavior, a change in these type of behaviors could be accomplished by identifying and altering those pieces of relational knowledge and those quick-and-dirty inferences that are driving automatic and irrational behavior (see Hogarth, 2018, for a discussion of how this idea is taking shape in research on the etiology and treatment of addiction, and Van Dessel, Hughes, & De Houwer, 2018, for an example of how it fosters innovations in behavior modification).

In sum, extending the realm of relational knowledge to include seemingly non-relational phenomena provides an alternative for dual-system models, which can have a profound impact on the application of psychological knowledge inside and outside of psychology. Although it will be difficult, if not impossible to demonstrate that all cognition is relational (see Box 1), merely reexamining the role of relational knowledge has merits because it reveals new avenues for research and application. I hope that the present paper encourages researchers to further exploit this potential.

Box 1. Questions for Future Research

1. Are there psychological phenomena that are not based on relational knowledge (e.g., perceptual and S-R binding, Perruchet effect)? If so, what knowledge are they based on and when does which type of knowledge matter?
2. Behavioral researchers have identified different types of relational behavior (i.e., non-arbitrarily applicable relational responding vs. arbitrarily applicable relational responding; e.g., Hayes et al., 2001). Does this mean that there are different types of relational knowledge (De Houwer et al., 2016)? If so, what are the differences and when does which type of relational knowledge mediate behavior?
3. What are the learning experiences from which the ability to think and act relationally emerge (see Hayes et al., 2001, for suggestions)?
4. How can deficits in relational cognition (and thus relational behavior) be remedied (see Hayes et al., 2001, and Gentner, 2016, for suggestions)?
5. How can relational knowledge be represented (e.g., in associative networks; see Hummel, 2010, for a discussion)?
6. In what ways can nonhuman animals think and act relationally (see Hughes & Barnes-Holmes, 2014, Lionello-DeNolf, 2009, Penn, Holyoak, & Povinelli, 2008, for a discussion)?
7. What is the role of relational knowledge in automatic goal-directed behavior?
8. What are the mental processes via which relational knowledge influences more automatic instances of behavior? If relational knowledge can be operated upon by both similarity-based retrieval processes and automatic inferences, when does which

type of process operate?

9. What is the nature of automatic (i.e., quick-and-dirty) inferences and how can they be influenced?
10. Can irrational and impulsive behaviors be changed by changing (the processes operating on) relational knowledge?

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Author Note

Jan De Houwer, Ghent University, Ghent, Belgium. The preparation of this paper was made possible by Methusalem Grant BOF16/MET_V/002 of Ghent University. I thank Pieter Van Dessel, Christian Frings, and an anonymous reviewer for comments on an earlier draft of the paper. Correspondence should be addressed to Jan De Houwer, Ghent University, Henri Dunantlaan 2, B-9000 Ghent, Belgium. Electronic mail can be sent to Jan.DeHouwer@UGent.be .